William & Mary
CHARTERED 1693

W&M ScholarWorks

Dissertations, Theses, and Masters Projects

Theses, Dissertations, & Master Projects

1969

The Soft Bottom Macrobenthic Community of Arthur Harbor, Antarctica

James K. Lowry
College of William and Mary - Virginia Institute of Marine Science

Follow this and additional works at: https://scholarworks.wm.edu/etd

Part of the Marine Biology Commons, and the Oceanography Commons

Recommended Citation

Lowry, James K., "The Soft Bottom Macrobenthic Community of Arthur Harbor, Antarctica" (1969). *Dissertations, Theses, and Masters Projects.* Paper 1539617416.
https://dx.doi.org/doi:10.25773/v5-84t0-mx53

This Thesis is brought to you for free and open access by the Theses, Dissertations, & Master Projects at W&M ScholarWorks. It has been accepted for inclusion in Dissertations, Theses, and Masters Projects by an authorized administrator of W&M ScholarWorks. For more information, please contact scholarworks@wm.edu.

THE SOFT BOTTOM MACROBENTHIC COMMUNITY
OF ARTHUR HARBOR, ANTARCTICA

A Thesis

Presented to

The Faculty of the School of Marine Science

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

By

James Kenneth Lowry

1969

APPROVAL SHEET

This thesis is submitted in partial fulfillment
of the requirements for the degree of
Master of Arts

James K. Lowry

Author

Approved, November 1969

Marvin L. Wass

Marvin L. Wass, Ph.D.

William J. Hargis, Jr.

William J. Hargis, Jr., Ph.D.

Dexter S. Haven

Dexter S. Haven, M.S.

Morris L. Brehmer

Morris L. Brehmer, Ph.D.

George C. Grant

George C. Grant, Ph.D.

ACKNOWLEDGEMENTS

The original idea for this thesis was conceived while working under the direction of Mr. Dexter Haven on benthic communities. Dr. William J. Hargis Jr. has lent his support to the project since its inception as has Dr. Marvin Wass, and I wish to thank them sincerely. My co-worker at Palmer Station, Mr. Lynn Suydam, was a constant source of encouragement and sound advice, and a congenial comrade during many long hours of field and laboratory work. A special debt of gratitude is extended to Mr. David Zwerner who graciously gave his time and talent to teach and direct me in the laboratory techniques needed to carry out this study.

I wish to extend sincere thanks to the taxonomists who generously gave their time and special talents to identify and confirm identifications of the species in this collection: Dr. J. L. Barnard, Amphipoda, USNM, Smithsonian Institution, Washington, D. C.; Dr. David Cook, Oligochaeta, Marine Biological Laboratory, Woods Hole, Massachusetts; Miss Nancy Cramer, Polychaeta, USNM, Smithsonian Institution, Washington, D. C.; Dr. R. K. Dell, Mollusca, Dominion Museum, Wellington, New Zealand; Dr. Lion Gardiner, Tanaidacea, Rutgers University, Newark, New Jersey; Dr. Robert Given, Cumacea, Santa Catalina Marine Biological Laboratory, Avalon, California; Dr. Louis S. Kornicker, Ostracoda, USNM, Smithsonian Institution, Washington, D. C. are all gratefully acknowledged.

I wish to thank Dr. Marvin Wass, Mr. Dexter Haven, Dr. William J. Hargis Jr., Dr. George Grant, Dr. John McCain and Mr. Donald Boesch for critically reading all or parts of the manuscript.

The field work for this study was supported by grant GA-684 from the National Science Foundation, Office of Antarctic Programs, Dr. William J. Hargis Jr., Principal Investigator.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Monthly grab samples (February, 1967 to January, 1968) taken at two localities, and sieved to 1 mm, have been used to describe the benthic soft bottom community of Arthur Harbor, Anvers Island, Antarctica. The bottom of the harbor was composed of soft mud. Physical parameters, such as bottom water temperature (yearly mean, -1.0°C) and bottom salinity (yearly mean, 34.10‰), exhibited little yearly variation.

Major components of the community were annelids, arthropods, and mollusks. The macrofaunal community exhibited a mean density of 7,629 indiv./m^2 at Station II and 6,285 indiv./m^2 at Station IV. Bioindex values utilizing numbers and volumes showed *Ampelisca bouvieri* and *Yoldia eightsi* to be dominant and characteristic members of the community. At least 18 species were recurrent members of the community occurring in at least 75% of all samples taken.

When all identified members of the community were considered, 89% were endemic to the Southern Ocean. Species of most minor groups (rhynchocoels, ostracods, cumaceans, nebaliaceans, pycnogonids, echinoderms, and ascidians) were totally endemic. In the better represented groups mollusks were 100% endemic, amphipods 95%, and annelids 77%.

Mean diversity values were relatively high. Mean redundancy values show the community to be near its theoretical maximum diversity. This indicates a stable, complex, and fairly diverse community, with individuals quite evenly distributed among species.

This community differs from previously described benthic communities in the Antarctic. It is a soft bottom community composed mainly of deposit feeders in the phyla Annelida, Arthropoda, and Mollusca. Previously described communities have been mainly hard bottom communities composed of sponges, coelenterates, and ectoprocts, and being for the most part suspension feeders.

THE SOFT BOTTOM MACROBENTHIC COMMUNITY

OF ARTHUR HARBOR, ANTARCTICA

INTRODUCTION

Collections from early Antarctic expeditions were necessarily used for taxonomic studies. Many of these expeditions made extensive collections along the Antarctic Peninsula. Scientific reports from the Belgian Antarctic Expedition 1897-1899, the Swedish South Polar Expedition 1901-1904, the French Antarctic Expeditions 1903-1905, and 1908-1910, the German South Polar Expedition 1910-1912, and the Discovery Expeditions from 1925 intermittently through 1950, form the bulk of our taxonomic knowledge of Antarctic invertebrates from this area. Since 1957 tremendous energy has been generated in Antarctic biology. With 13 countries actively conducting research in the Antarctic, more animals have probably been collected since 1957 than in all previous years (Dearborn, 1968).

Eight hundred and seventy five nominate species of mollusks (Powell, 1965), 475 polychaetes (Hartman, 1966), 310 amphipods, 130 isopods, 100 pycnogonids (Ekman, 1953), 270 echinoderms (Dearborn, 1967) and 126 tunicates (Kott, 1969) are known from the Antarctic-Subantarctic fauna. Despite these advances in taxonomy no significant studies in benthic invertebrate ecology were conducted until the late fifties, first by Beliaev and Uschakov (Uschakov, 1963) and more recently by Dearborn (1965a, 1967) and Bullivant (1967). Uschakov summarized the Russian benthic studies done in the East Antarctic while the work of Dearborn and Bullivant was conducted in the Ross Sea. From these studies the marine benthos has been characterized as highly diverse with many endemic species, many of which exhibit direct development. The communities are dominated by suspension feeders such as sponges, bryozoans and coelenterates forming thick mats over the bottom (Dearborn, 1968).

The present study was carried out on the soft mud bottom of Arthur Harbor, Anvers Island, Antarctica, where, because of the substrate, one would generally expect deposit feeders to replace suspension feeders. Polychaetes, mollusks and infaunal crustaceans normally dominate such sites.

The objective has been a detailed study of the benthic community, emphasizing species composition and community structure. Petersen (1911, 1913, 1914), Mare (1942) and Thorson (1957) have provided the traditional basis for this study and the work of Sanders (1956, 1960, 1968), Patten (1962), Margalef (1968) and Dunbar (1968) have provided more modern approaches. In the main the objective has been realized; however, the complete collection has not been utilized and it is hoped the study may be expanded further.

MATERIALS AND METHODS

Four stations were established on the western side of Arthur Harbor (Fig. 1) (Table I). A fifth station was planned on the eastern side, but climate prohibited its occupation. Stations were sampled monthly from a small boat or through ice holes during winter months. A Petersen grab which sampled an area of approximately 0.06 m^2 and a maximum volume of approximately 4500 cm^3 was used. Actual volumes were measured in a graduated bucket. Samples for sediment analysis were obtained with a small snapper grab (volume 38 cm^3). Analysis was carried out at the Virginia Institute of Marine Science (VIMS) using the technique outlined in Krumbein and Pettijohn (1938), and modified by Haven (per. comm.).

Water samples for salinity were collected at the surface and bottom using a Kemmerer bottle. Sample bottles were sealed with paraffin and stored until analysis could be carried out at VIMS using a RS-7A conductivity unit. Water temperatures were obtained from the Kemmerer bottle as it was brought aboard. Sediment temperatures were obtained in a similar manner from the Petersen grab.

Sediment samples were sieved through U. S. Standard Screens with pore openings of 2, 1, and 0.5 mm. In this study only the 2 and 1 mm samples from Station II and Station IV have been used. The study was so confined because of the prohibitive time involved in working with animals collected on screen sizes below 1 mm. Station II and Station IV were selected because they contained the

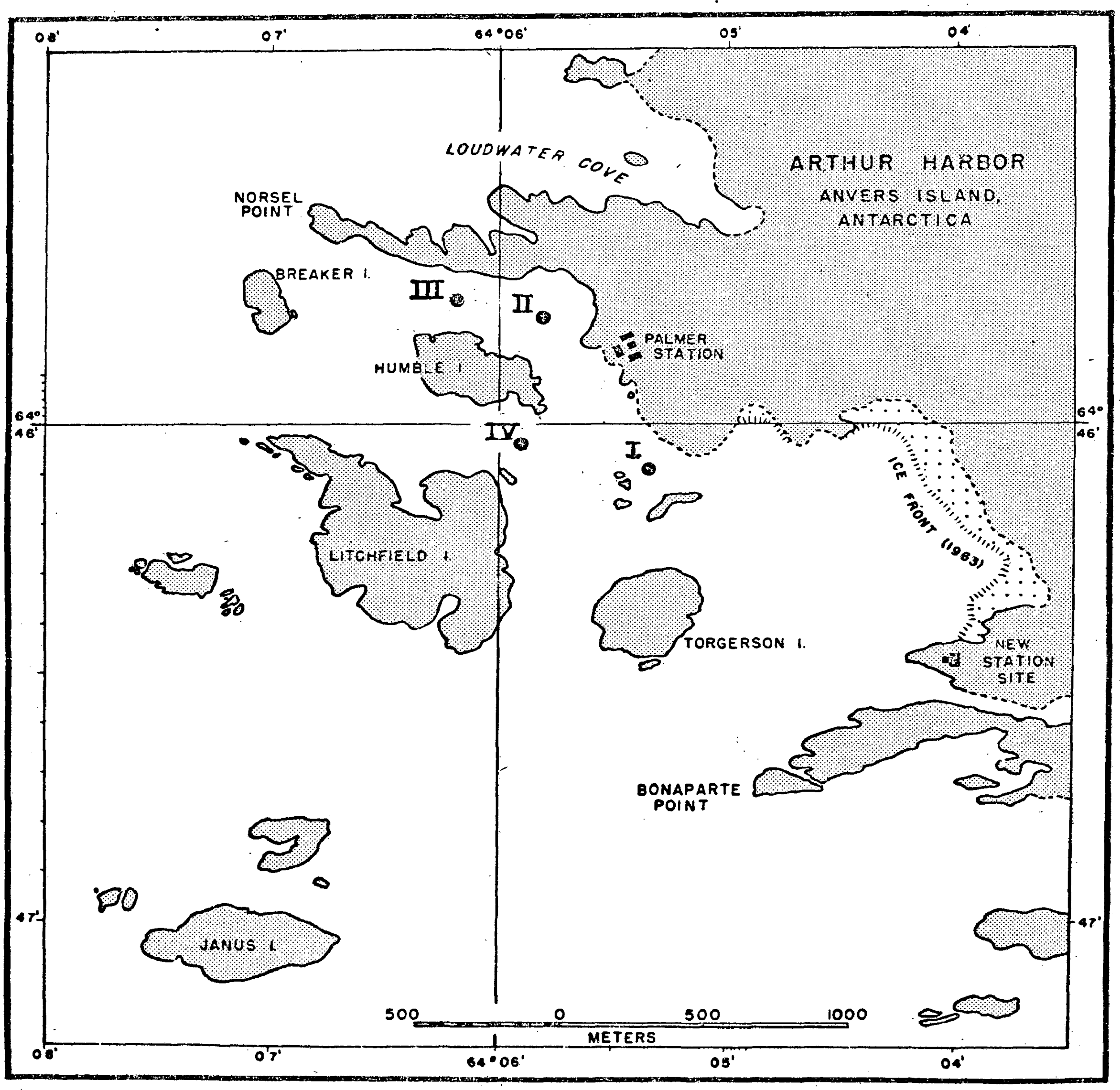

Figure 1. Map of Arthur Harbor, Antarctica, showing the stations at which monthly collections were made from February 1967 to January 1968.

Table I. Coordinates and depth of the Arthur Harbor benthic stations.

	Longitude	Latitude	Depth
Station I	64°05'38"W	64°46'05"S	26 m
Station II	64°05'51"W	64°45'49"S	32 m
Station III	64°06'17"W	64°45'46"S	40 m
Station IV	64°05'54"W	64°46'02"S	35 m

most complete set of samples and because they appeared, from preliminary work, to be the two most divergent stations. It is intended, as was stated earlier, that the collection be eventually analyzed using all stations and all screen sizes. The washing procedure took place on the boat landing from February to May, using salt water, but by June climatic conditions forced this operation into the laboratory, where fresh water was used. Sieved samples were fixed in 10% formalin. The animals were then picked from the samples using a binocular dissecting microscope. As a sample was analyzed, species were sorted into separate vials containing 70% EtOH plus 5% glycerine.

Tentative identifications were made by the author where possible. In most cases final identifications were made by specialists (see acknowledgements). However, identifications of groups not mentioned in the acknowledgements, except the Polychaeta, are those of the author. Most animals identified to genus only are regarded as new species. The two most abundant members of the community are the annelids, _Apistobranchus sp_. and _Thallasodrilus sp_., both of which are undescribed species, and this is true of other common animals such as the polychaetes, _Paraonis sp_. and _Ammotrypane sp_., the ostracod, _Philomedes sp_., the cumacean, _Eudorella sp_., and the amphipods, _Harpinia sp_. _A_, _Harpiniopsis sp_. and _Urothöe sp_. The common amphipod, _Megamphopus sp_., is probably also a new species, however this is difficult to determine until males are discovered (Barnard, per. comm.). The oligochaete, _Thallasodrilus sp_., and the ostracods, _Philomedes sp_. and _Parasterope sp_. are in the process of description by Dr. David Cook and Dr. Louis Kornicker respectively.

Because of the taxonomic importance of the collection, dry weights were not considered. Furthermore, wet weights did not give satisfactory replication. Subsequently volumes were measured employing a method devised by Mr. Zwerner and the author. A reservoir supplied 70% EtOH to two self-filling burettes, one measuring to 0.1 ml and the other to 0.01 ml. The former was used in measuring animals from the 2 mm screen, the latter from the 1 mm screen. Large representative lots of each species to be measured were selected. A sample was blotted dry and placed in a vial marked at a predetermined volume. Liquid was released from the burette until it reached the mark. Subtraction of the burette reading from the known volume of the vial gave the volume of the sample. Three measurements were normally made on each sample and the mean calculated. Volume per individual was then calculated for each species measured and these figures were used to extrapolate volumes of small samples not measured.

Monthly data obtained with the Petersen grab were combined for calculating bioindex values and for ranking species by number. Diversity was used to determine the stability and complexity of the community by month throughout the study. Data on seasonal abundance and aspects of reproductive periodicity were collected but not discussed.

Natural history observations were made during the year on birds and seals in Arthur Harbor. These observations extended to intertidal invertebrates and fish captured in traps, thus lending continuity to the study of the benthic community.

RESULTS

Sediments

The sides of Arthur Harbor are in many places rocky submarine cliffs which prohibit the accumulation of sediment. Sediment is mainly found below 15 m, filling the bottom of the channels between the barrier islets. In a few places small coves may accumulate sediment. Station II was located on the NNE side of the Norsel-Humble channel (Fig. 1), at the mouth of such a cove. A fan-shaped sediment bed extended from a small melt water stream into the cove. The bottom varied little in consistency (Table II); mean yearly values showed 7.27% sand, range 1.88-13.83%; 72.12% silts, range 69.12-78.22%; and 20.55% clay, range 15.94-25.95%.

Station IV was located at the eastern end of the Humble-Litchfield channel where it began a slight rise into a shallower rocky bottom. The bottom at Station IV was somewhat rocky so that sediment appeared to be in patches. Mean yearly values showed sand 34.91%, range 7.69-48.75%; silt 54.59%, range 41.19-77.53%; and clay 10.49%, range 6.87-15.56%. Thus both stations have basically soft bottoms. Station II appears more consistent for all samples and is largely silty-clay, whereas Station IV is apparently composed of patches of sediment varying in composition but mainly silty-sand. No seasonal trends were evident at either station.

Homogeneity

To determine if homogeneity occurred throughout the samples an

Table II. Particle size analysis by percent weight for Station II and Station IV.

Station II 1967	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Mean
% Sand <1.9mm>62.5u	12.30	4.25	5.82	8.30	6.14	1.88	8.66	2.42	9.69	13.83	7.20	7.27
% Silt <62.5u>4u	70.84	72.80	78.22	72.18	71.14	73.57	69.19	71.62	72.83	69.12	71.82	72.12
% Clay <4u	16.86	22.94	15.94	19.52	22.71	24.53	22.13	25.95	17.48	17.04	20.97	20.55
% Silt-Clay <62.5u	87.70	95.74	94.16	91.70	93.85	98.10	91.32	97.57	90.31	86.16	92.79	
Station IV												
% Sand	19.93	48.75	49.59	7.69	31.94	39.89	39.51	43.27	23.43	44.70	35.33	34.91
% Silt	70.65	41.19	43.18	77.53	56.56	44.53	49.60	46.69	68.99	48.43	53.12	54.59
% Clay	9.40	10.06	7.23	14.78	11.48	15.56	10.88	10.03	7.57	6.87	11.54	10.49
% Silt-Clay	80.05	51.25	50.41	92.31	68.04	60.09	60.48	56.72	76.56	55.30	64.66	

index of affinity was calculated and subsequently plotted on a trellis diagram, Fig. 2 (Sanders, 1960). Index values were not particularly high (mean 40.41%), mainly because there were no overwhelmingly abundant species. Ranking the samples indicated that Station II and Station IV had equally high inter- and intra-affinities.

Station IV-April exhibited consistently low affinities with most other samples. This was caused by a percentage decrease in recurrent species such as _Ampelisca bouvieri_, _Apistobranchus sp_., and _Yoldia eightsi_, and an increase in epifaunal species not normally found in other samples. Station II-January also exhibited low indices of affinity. It contained a low number of species although those present were recurrent. It also contained an unusually large number of _Capitella perarmata_, a species which occurred sporadically and usually in low numbers. Its rather high affinity for Station II-March was due to a high percentage of _A. bouvieri_ and _Megamphopus sp_. in both samples.

Ranking

It is difficult to assess species importance in a community objectively. Investigators have devised different methods in response to the problem. Sanders (1956, 1960) feels that numbers are a more valid measure than weight in a quantitative sample. His data imply that "the presence or absence of the rare, randomly distributed large animals effectively determines the biomass of the sample". In the Arthur Harbor community there are at least 18 recurrent species. These 18 species make up 79.34% of the community by number and 61.02% by volume, whereas in Sanders (1960) study less than 0.15% of the community by number made up 55.17% of the biomass.

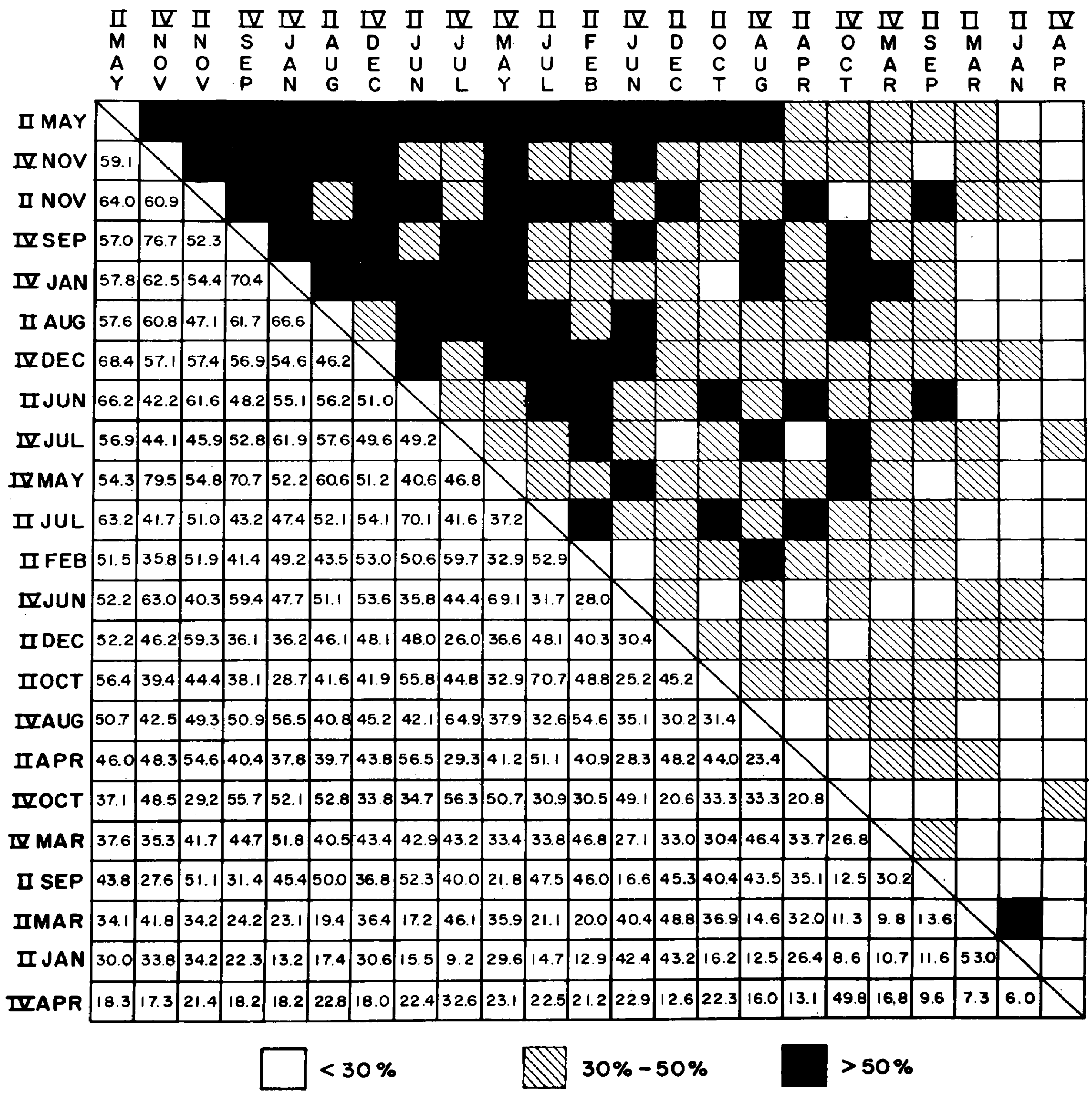

Figure 2. A comparison of the average faunal index of affinity at Station II and Station IV.

Consequently it was felt that numbers and volume should contribute equally in the analysis and the method of Richards and Riley (1967) was chosen. The system is based on ten ranks. A species ranking number one in a sample for both number and volume is given ten points for each, a rank of two is given nine points, etc. The values are then multiplied times their frequency and samples are added. Sums of numbers and volumes are then multiplied to give a bioindex value. *Ampelisca bouvieri* at Station II is used as an example.

N	V
2 x 10 = 20	2 x 10 = 20
1 x 9 = 9	2 x 9 = 18
2 x 8 = 16	1 x 8 = 8
1 x 3 = 3	2 x 7 = 14
1 x 2 = 2	2 x 5 = 10
1 x 1 = 1	2 x 3 = 6
51	76

51 x 76 = 3876, bioindex value

At Station II with 12 samples the highest possible score was 14,400. The highest score actually received was 3,876 by *Ampelisca bouvieri*. At Station IV with 11 samples the highest possible score was 12,100. *A. bouvieri* was again the high scorer with 3,021 (Tables III and IV).

Other high scorers at Station II include the protobranch *Yoldia eightsi* (2), the large tubificid *Thalassodrilus sp.* (3), the polychaetes *Rhodine loveni* (4), maldanid #1 (5), *Apistobranchus sp.* (6), and *Maldane sarsi* (10), the amphipods *Megamphopus sp.* (7) and *Harpinia sp. A* (9), and the cumacean *Eudorella sp.* (8).

At Station IV, 7 of the top 10 species are polychaetes. These include *Apistobranchus sp.* (2), *Haploscoloplos kerguelensis* (3), *Aglaophamous ornatus* (5), *Rhodine loveni* (7), maldanid #1 (8), *Lumbriclymenella robusta* (9), and *Ammotrypane sp.* (10). The exceptions include *Ampelisca bouvieri* (1), *Yoldia eightsi* (4), and *Heterophoxus videns* (6).

Table III. Ranking of species from 12 monthly samples at Station II utilizing number (N) and volume (V). Species are listed according to their bioindex score.

	Rank of Abundance 1		2		3		4		5		6		7		8		9		10				
	Score 10		9		8		7		6		5		4		3		2		1		Total Value	Total Value	Bioindex
	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	Score
Ampelisca bouvieri	2	2	1	2	2	1	-	2	-	-	-	2	-	-	1	2	1	-	1	-	51	76	3876
Yoldia eightsi	-	4	-	5	1	-	1	-	1	-	2	-	-	-	2	-	1	-	-	-	39	85	3315
Thallasodrilus sp.	4	-	4	-	1	-	-	-	1	1	-	1	-	2	-	3	-	1	-	2	90	32	2880
Rhodine loveni	-	-	1	-	-	1	2	3	1	-	1	-	1	3	1	1	-	2	1	-	42	48	2016
Maldanid #1	-	-	-	-	-	-	1	1	2	4	-	1	-	1	2	1	3	1	1	-	32	45	1440
Apistobranchus sp.	2	-	2	-	1	-	1	-	2	1	1	1	2	1	-	1	-	-	-	-	78	18	1404
Megamphopus sp.	-	-	2	-	2	1	-	-	-	-	1	1	-	1	-	2	-	-	-	-	39	23	897
Eudorella sp.	-	-	-	-	2	-	2	1	1	1	2	-	2	-	2	-	1	-	-	1	56	14	784
Harpinia sp. A	-	-	-	-	2	-	2	-	-	-	-	-	1	-	1	1	2	1	1	3	42	8	336
Maldane sarsi	-	-	-	-	1	1	1	-	1	-	1	1	-	-	-	-	-	-	1	-	12	26	312
Lumbriclymenella robusta	-	-	-	1	-	1	-	1	-	1	-	2	1	-	1	-	-	-	-	-	7	40	280
Haploscoloplos kerguelensis	1	-	-	-	-	-	-	-	1	-	-	-	1	-	1	1	1	1	1	2	26	7	182
Capitella perarmata	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	16	9	144
Harpiniopsis sp.	-	-	-	-	-	-	-	-	1	-	3	-	1	1	-	-	1	-	1	-	28	4	112
Paraonis sp.	2	-	1	-	1	-	-	-	1	-	-	-	-	-	2	-	-	1	1	-	50	2	100
Heterophoxus videns	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1	1	1	2	-	15	5	75
Methalimedon sp.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	1	2	-	8	7	56
Philomedes sp.	-	-	-	-	-	-	1	-	-	-	1	-	1	-	2	-	1	1	-	-	24	2	48
Aglaophamous ornatus	-	-	-	-	-	3	-	-	-	2	-	-	-	1	-	1	-	-	-	2	-	45	45
Barrukia cristata	-	-	-	1	-	2	-	1	-	1	-	-	-	1	-	-	-	-	-	-	-	42	42
Ammotrypane sp.	-	-	-	-	-	-	1	-	1	-	1	-	3	-	1	-	-	-	2	-	35	-	35
Abatus cavernosus	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	26	26
Nototanais antarcticus	1	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	2	-	25	-	25
Artacama proboscidea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	9	18

	Rank of Abundance 1		2		3		4		5		6		7		8		9		10		Total Value	Total Value	Bioindex Score
	Score 10		9		8		7		6		5		4		3		2		1				
	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	
Eugyra kerguelensis	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	17
Pagatenidae n.gn.	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	13	-	13
Serolis polita	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	1	-	-	-	12	12
Sterechinus neumayeri	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10
Laternula elliptica	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10
Molgula gigantea	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10
Glyptonotus antarcticus	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	9
Kuplocheira sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-	8	-	8
Harpinia sp. B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	4	2	8
Neobuccinum eatoni	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	7	7
Monoculodes sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	1	6	1	6
Subonoba sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	5	-	5
Paramoera serraticauda	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	5	-	5
Brada villosa	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	4
Haplocheira sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	4
Orchomene franklini	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	4
Echinozone spinosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	3	3
Rhodine antarctica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	-	3
Leptognathia spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	-	3
Goldfingia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Thracia meridionalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Thyasira bongraini	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Vaunthompsonia meridionalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Schradieria gracilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1

Table IV. Ranking of species from 11 monthly samples at Station IV utilizing number (N) and volume (V). Species are listed according to their bioindex score.

	Rank of Abundance																						
	1		2		3		4		5		6		7		8		9		10				
	Score																				Total Value	Total Value	Bioindex
	10		9		8		7		6		5		4		3		2		1				
	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	Score
Ampelisca bouvieri	2	2	2	1	1	3	1	-	-	-	-	-	-	-	-	1	-	-	-	1	53	57	3021
Apistobranchus sp.	7	-	3	-	1	-	-	-	1	-	1	-	-	2	-	1	-	2	-	2	105	28	2940
Haploscoloplos kerguelensis	1	-	3	-	-	-	4	1	-	-	-	1	2	1	-	3	-	1	-	2	80	29	2320
Yoldia eightsi	-	7	-	2	-	1	-	-	1	-	1	-	1	-	1	-	-	-	-	-	18	96	1728
Aglaophamous ornatus	-	1	-	1	-	3	-	3	-	1	-	1	-	-	2	1	1	-	2	1	10	78	780
Heterophoxus videns	1	-	1	-	1	-	-	1	-	-	-	-	1	2	1	-	-	1	-	-	34	17	578
Rhodine loveni	-	-	-	-	-	-	-	1	3	3	1	-	-	-	-	-	-	-	-	-	23	25	575
Maldanid #1	-	-	-	-	-	-	-	1	-	1	1	1	-	-	1	2	1	1	4	1	14	27	378
Lumbriclymenella robusta	-	-	-	1	-	1	-	1	-	2	-	1	1	-	-	-	1	-	-	-	6	41	246
Ammotrypane sp.	-	-	1	-	1	-	-	-	1	-	-	-	2	-	1	-	-	2	1	-	43	4	172
Barrukia cristata	-	-	-	1	-	-	-	1	-	-	-	1	-	1	1	-	1	-	-	-	5	25	125
Ampelisca eschrichti	-	-	-	-	-	-	-	1	-	1	-	1	1	1	-	-	-	-	1	-	5	22	110
Terebellides stroemii	-	-	-	1	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	5	20	100
Harpinia sp. A	-	-	-	-	2	-	1	-	2	-	1	-	-	-	-	-	-	-	-	2	40	2	80
Limopsis lillei	-	-	-	1	-	-	-	-	-	-	-	1	1	-	-	-	-	-	1	-	5	14	70
Margarella antarctica	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-	1	-	-	-	6	11	66
Eunoe opalina	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	1	-	7	8	56
Thallasodrilus sp.	-	-	1	-	3	-	1	-	-	-	1	-	1	-	1	-	1	-	-	1	54	1	54
Methalimedon sp.	-	-	-	-	-	-	-	-	1	-	2	-	-	-	2	-	2	-	-	2	26	2	52
Megamphopus sp	-	-	1	-	-	-	1	-	-	-	-	-	-	-	1	-	-	1	1	-	20	2	40
Harpiniopsis sp.	-	-	-	-	-	-	1	-	1	-	1	-	3	-	3	-	-	-	-	-	39	-	39
Holothurian	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	3	12	36
Cyclocardia astartoides	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	-	2	16	32
Paraonis sp.	-	-	-	-	1	-	-	-	2	-	-	-	-	-	1	-	2	-	1	-	28	-	28

	Rank of Abundance 1		2		3		4		5		6		7		8		9		10		Total Value	Total Value	Bioindex
	Score 10		9		8		7		6		5		4		3		2		1				
	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	Score
Echinozone spinosa	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	1	1	-	1	2	14	28
Neobuccinum eatoni	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	9	27
Thracia meridionalis	-	1	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	1	-	1	22	22
Urothöe sp.	-	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-	2	-	3	-	21	-	21
Kellia nimrodiana	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	5	4	20
Polycirrus sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2	-	-	14	4	18
Eudorella sp.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	-	1	-	2	-	16	-	16
Octobranchus antarcticus	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	9	-	9
Odontaster validus	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	8	8
Thyasira bongraini	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	7	-	7
Philomedes sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	-	6	-	6
Vaunthompsonia inermis	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	6	-	6
Leptognathia spp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	6	-	6
Laternula elliptica	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	5	5
Subonoba sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	5	-	5
Tharyx epitoca	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	4
Laeospira sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	4
Exogone miniscula	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	4
Parasterope sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	4
Diastylis sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	4
Haliacris sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	4
Eusirus antarcticus	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4	-	4
Priapulus caudatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	3
Thelepus cincinnatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	3
Pariphemedia integricauda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	3
Panoploea joubini	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	3
Orchomene franklini	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	3
Monoculodes sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	3
Pentanymphon antarcticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	3
Maldane sarsi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	3	3
Goldfingia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2

	Rank of Abundance 1		2		3		4		5		6		7		8		9		10		Total Value	Total Value	Bioindex
Score	10		9		8		7		6		5		4		3		2		1				
	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	Score
Chiton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Nototanais antarcticus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Kuplocheira sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Djerboa fucipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Wandelia crassipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Polychaete #27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Praxillella kerguelensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1
Flabelligera gourdoni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1

SCUBA divers in Arthur Harbor have reported the isopod _Serolis polita_ and the lamellibranch _Laternula elliptica_ to be well represented on the soft bottom (McCain, per. comm.). It is possible that these two species were not adequately sampled by the Petersen grab. _S. polita_ is mobile and might escape the grab, while _L. elliptica_ may bury up to 1 meter below the surface and thus be inaccessible to the grab.

Diversity

It is apparent from Tables V and VI that the community under discussion has many species, with individuals distributed so that dominance is shared by more than one species and the number of individuals decreases smoothly from most abundant to least abundant. When this situation exists the community is said to contain much information. A measure of the information is provided by Shannon (1948):

$$H' = -\Sigma\, p_i \log p_i$$

In this formula H' represents diversity per individual and p_i represents the true proportions of the individuals in the population. However, p_i may be estimated by $p_i = \frac{n_i}{N}$ where N equals the total number of individuals and n_i represents the number of individuals of i^{th} species in a population of (n_1, n_2, n_3 ... n_i). Thus, H' can be approximated by $\overline{H}$ (Patten, 1962):

$$\overline{H} = -\Sigma \frac{n_i}{N} \log_{10} \frac{n_i}{N} \qquad \text{or} \qquad \overline{H} = \frac{c}{N} [N \log_{10} N - \Sigma\, n_i \log n_i]$$

In the latter equation, c (3.321928) is the factor for converting $base_{10}$ logarithms to base 2 ("bits") which are used in this study.

Patten (1962) went further by establishing formulae to calculate maximum and minimum diversities for a given population. These formulae are based on certain inherent properties of diversity. Thus if all

Table V. The structure of the Arthur Harbor macrofaunal community at Station II. Species are listed in order of abundance. This table represents the accumulated total for 12 monthly samples from February 1967 to January 1968.

Rank by No.	Species	No. Indiv.	% of Fauna by No.	Cumul. % by No.
1	Thallasodrilus sp.	839	15.58	15.58
2	Apistobranchus sp.	510	9.47	25.05
3	Ampelisca bouvieri	488	9.06	34.11
4	Eudorella sp.	328	6.09	40.20
5	Megamphopus sp.	324	6.02	46.22
6	Paraonis sp.	281	5.22	51.44
7	Nematodes	277	5.14	56.58
8	Rhodine loveni	246	4.57	61.15
9	Harpinia sp. A	211	3.92	65.07
10	Maldanid #1	155	2.88	67.95
11	Yoldia eightsi	149	2.77	70.72
12	Capitella perarmata	146	2.71	73.43
13	Philomedes sp.	144	2.67	76.10
14	Ammotrypane sp.	137	2.54	78.64
15	Nototanais antarcticus	129	2.40	81.04
16	Harpiniopsis sp.	122	2.26	83.30
17	Haploscoloplos kerguelensis	118	2.19	85.49
18	Heterophoxus videns	94	1.74	87.23
19	Monoculodes sp.	70	1.30	88.53
20	Maldane sarsi	68	1.26	89.79
21	Methalimedon sp.	54	1.00	90.79
22	Kuplochiera sp.	42	0.78	91.57
23	Rhodine antarctica	31	0.58	92.15
24	Harpinia sp. B	31	0.58	92.73
25	Thyasira bongraini	26	0.48	93.21
26	Orchomene franklini	25	0.46	93.67
27	Pagetinidae n.gn.	22	0.41	94.09
28	Lumbriclymenella robusta	22	0.41	94.49
29	Aglaophamous ornatus	21	0.39	94.88
30	Haplocheira sp.	21	0.39	95.27
31	Haliacris sp.	18	0.33	95.60
32	Goldfingia sp.	14	0.26	95.86
33	Vaunthompsonia meridionalis	14	0.26	96.12
34	Barrukia cristata	13	0.24	96.36
35	Leptognathia spp.	12	0.22	96.58
36	Artacama proboscidea	11	0.20	96.78
37	Schradieria gracilis	11	0.20	96.98
38	Axiothella antarctica	10	0.18	97.16
39	Subonoba sp.	10	0.18	97.34
40	Priapulus caudatus	9	0.17	97.51

Rank by No.	Species	No. Indiv.	% of Fauna by No.	Cumul. % by No.
41	Thracia meridionalis	9	0.17	97.68
42	Vaunthompsonia inermis	9	0.17	97.85
43	Eugyra kerguelensis	9	0.17	98.02
44	Paramoera serraticauda	8	0.15	98.17
45	Brada villosa	7	0.13	98.30
46	Praxillella kerguelensis	6	0.11	98.41
47	Cyamiocardium denticulatum	6	0.11	98.52
48	Urothöe sp.	6	0.11	98.63
49	Serolis polita	5	0.09	98.72
50	Echinozone spinosa	5	0.09	98.81
51	Monoculodes scabriculosus	5	0.09	98.90
52	Laternula elliptica	4	0.07	98.97
53	Nebaliella extrema	4	0.07	99.04
54	Lumbrineris sp.	3	0.06	99.10
55	Eulalia subulifera	3	0.06	99.16
56	Parasterope sp.	3	0.06	99.22
57	Diastylis sp.	3	0.06	99.28
58	Metaleptamphopus pectinatus	3	0.06	99.34
59	Abatus cavernosus	3	0.06	99.40
60	Sterechinus neumayeri	3	0.06	99.46
61	Tharyx epitoca	2	0.04	99.50
62	Euphionella sp.	2	0.04	99.54
63	Octobranchus antarcticus	2	0.04	99.58
64	Kellia nimrodiana	2	0.04	99.62
65	Neobuccinum eatoni	2	0.04	99.66
66	Philine alata	2	0.04	99.70
67	Exspina sp.	2	0.04	99.74
68	Glyptonotus antarcticus	2	0.04	99.78
69	? Uristes sp.	2	0.04	99.82
70	Paraphoxus fuegiensis	2	0.04	99.86
71	Turbellarian	1	0.02	99.88
72	Lineus corrugatus	1	0.02	99.90
73	Eunereis sp.	1	0.02	99.92
74	Terebella ehlersi	1	0.02	99.94
75	Thelepides koehleri	1	0.02	99.96
76	? Cryptocope sp.	1	0.02	99.98
77	Thaumatelson cultricauda	1	0.02	100.00
78	Molgula gigantea	1	0.02	100.02

Total Species	78
Total Individuals	5385
Number Indiv./m^2	7629

Table VI. The structure of the Arthur Harbor macrofaunal community at Station IV. Species are listed in order of abundance. This tables represents the accumulated total for 11 monthly samples from March 1967 to January 1968.

Rank by No.	Species	No. Indiv.	% of Fauna by No.	Cumul. % by No.
1	Apistobranchus sp.	987	24.27	24.27
2	Haploscoloplos kerguelensis	325	7.99	32.26
3	Nematodes	286	7.03	39.29
4	Ampelisca bouvieri	284	6.98	46.27
5	Thallasodrilus sp.	214	5.26	51.53
6	Heterophoxus videns	211	5.19	56.72
7	Ammotrypane sp.	189	4.65	61.37
8	Harpinia sp. A	133	3.27	64.64
9	Megamphopus sp.	128	3.15	67.79
10	Rhodine loveni	117	2.88	70.67
11	Harpiniopsis sp.	115	2.83	73.50
12	Paraonis sp.	106	2.61	76.11
13	Methalimedon sp.	96	2.36	78.47
14	Urothöe sp.	81	1.99	80.46
15	Maldanid #1	70	1.72	82.18
16	Eudorella sp.	68	1.67	83.85
17	Yoldia eightsi	59	1.45	85.30
18	Aglaophamous ornatus	44	1.08	86.38
19	Leptognathia spp.	42	1.03	87.41
20	Thyasira bongraini	38	0.93	88.34
21	Polycirrus sp.	35	0.86	89.20
22	Octobranchus antarcticus	35	0.86	90.06
23	Monoculodes sp.	32	0.79	90.85
24	Philomedes sp.	31	0.76	91.61
25	Echinozone spinosa	26	0.64	92.25
26	Lumbriclymenella robusta	24	0.59	92.84
27	Ampelisca eschrichti	23	0.56	93.40
28	Priapulus caudatus	18	0.44	93.84
29	Terebellides stroemii	17	0.42	94.26
30	Kuplocheira sp.	16	0.39	94.65
31	Limopsis lillei	15	0.37	95.02
32	Barrukia cristata	12	0.30	95.32
33	Vaunthompsonia meridionalis	11	0.27	95.59
34	Diastylis sp.	11	0.27	95.86
35	Goldfingia sp.	10	0.24	96.10
36	Tharyx epitoca	10	0.24	96.34
37	Polychaete #27	9	0.22	96.56
38	Cyclocardium astartoides	9	0.22	96.78
39	Vaunthompsonia inermis	9	0.22	97.00
40	Maldane sarsi	8	0.20	97.20

Rank by No.	Species	No. Indiv.	% of Fauna by No.	Cumul. % by No.
41	Praxillella kerguelensis	8	0.20	97.40
42	Thracia meridionalis	8	0.20	97.60
43	Paramoera serraticauda	8	0.20	97.80
44	Cyamiocardium denticulatum	7	0.17	97.97
45	Eunoe opalina	6	0.15	98.12
46	Nototanais antarcticus	6	0.15	98.27
47	Subonoba sp.	5	0.12	98.39
48	Margarella antarctica	4	0.10	98.49
49	Eulalia subulifera	3	0.07	98.56
50	Thelepides koehleri	3	0.07	98.63
51	Kellia nimrodiana	3	0.07	98.70
52	Neobuccinum eatoni	3	0.07	98.77
53	Nebaliella extrema	3	0.07	98.84
54	Orchomene franklini	3	0.07	98.91
55	Brada villosa	2	0.05	98.96
56	Exogone miniscula	2	0.05	99.01
57	Laeospira sp.	2	0.05	99.06
58	Potamilla sp.	2	0.05	99.11
59	Austrolaenilla antarctica	2	0.05	99.16
60	Polychaete #32	2	0.05	99.21
61	Haliacris sp.	2	0.05	99.26
62	Parasterope sp.	2	0.05	99.31
63	Schradieria gracilis	2	0.05	99.36
64	Eusirus antarcticus	2	0.05	99.41
65	Holothurian	2	0.05	99.46
66	Capitella perarmata	1	0.02	99.48
67	Flabelligera gourdoni	1	0.02	99.50
68	Axiothella antarctica	1	0.02	99.52
69	Lumbrineris sp.	1	0.02	99.54
70	Eunereis sp.	1	0.02	99.56
71	Thelepus cincinnatus	1	0.02	99.58
72	Ampharete kerguelensis	1	0.02	99.60
73	Amphicteis gunneri antarctica	1	0.02	99.62
74	Polychaete #28	1	0.02	99.64
75	Polychaete #29	1	0.02	99.66
76	Anemone	1	0.02	99.68
77	Chiton	1	0.02	99.70
78	Laternula elliptica	1	0.02	99.72
79	Amauropsis grisea	1	0.02	99.74
80	? Uristes sp.	1	0.02	99.76
81	Pariphemedia integricauda	1	0.02	99.78
82	Djerboa fucipes	1	0.02	99.80
83	Wandelia crassipes	1	0.02	99.82
84	Panoploea joubini	1	0.02	99.84
85	Pentanymphon antarcticum	1	0.02	99.86
86	Odontaster validus	1	0.02	99.88
	Total Species	86		
	Total Individuals	4067		
	Number Indiv./m^2	6285		

individuals in a population belong to one species (m=1) then diversity is null (H=0). If m>1, then diversity is minimal when all individuals belong to one species except one to each remaining species.

$$\overline{H}_{min} = \frac{1}{N} [\log N! - \log [N - (m-1)]!]$$

The other extreme of maximum diversity exists when m>1 and the individuals in the population are equally distributed among the species.

$$\overline{H}_{max} = \frac{1}{N} [\log N! - m \log (\frac{N}{m})!]$$

As the number of individuals approaches equal distribution, $\frac{N}{m}$ approaches 1. When N = m then $\overline{H}_{max}$ = log N!

Patten (1962) devised a formula to measure at what point between $\overline{H}_{max}$ and $\overline{H}_{min}$ a sample might fall.

$$R = \frac{\overline{H}_{max} - \overline{H}}{\overline{H}_{max} - \overline{H}_{min}}$$

R (redundancy) will fall in a range from 0 to 1 where redundancy is 0 when diversity is equal to the theoretical maximum and 1 when theoretical minimum diversity is achieved.

At Station II the yearly mean diversity equaled 3.9866 bits/ individual as compared with 3.7500 bits/individual at Station IV. Yearly mean redundancy values equal 0.1947 at Station II and 0.2370 at Station IV. These values indicate high diversities at both stations with redundancy approaching 0.

Fig. 3 and fig. 4 illustrate variations in diversity throughout the year. Reductions in diversity occurred at Station II during middle austral summer and late winter-early spring. These changes also occurred at Station IV although they were not as pronounced. The increased abundance of *Ampelisca bouvieri*, *Apistobranchus* sp., *Thallasodrilus* sp., *Eudorella* sp. and *Capitella perarmata* is responsible for these changes.

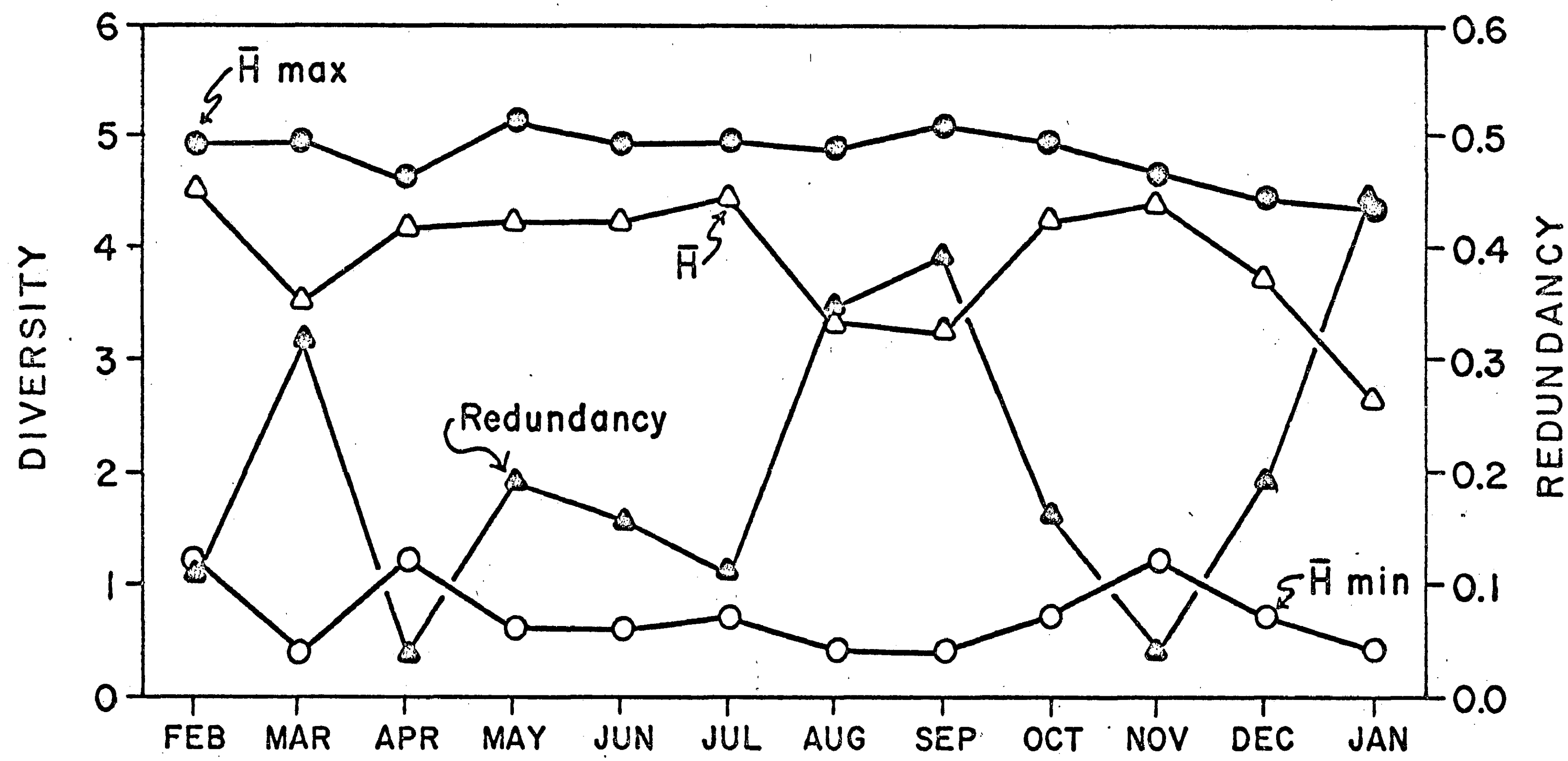

Figure 3. Monthly diversity and redundancy values at Station II, February 1967 - January 1968.

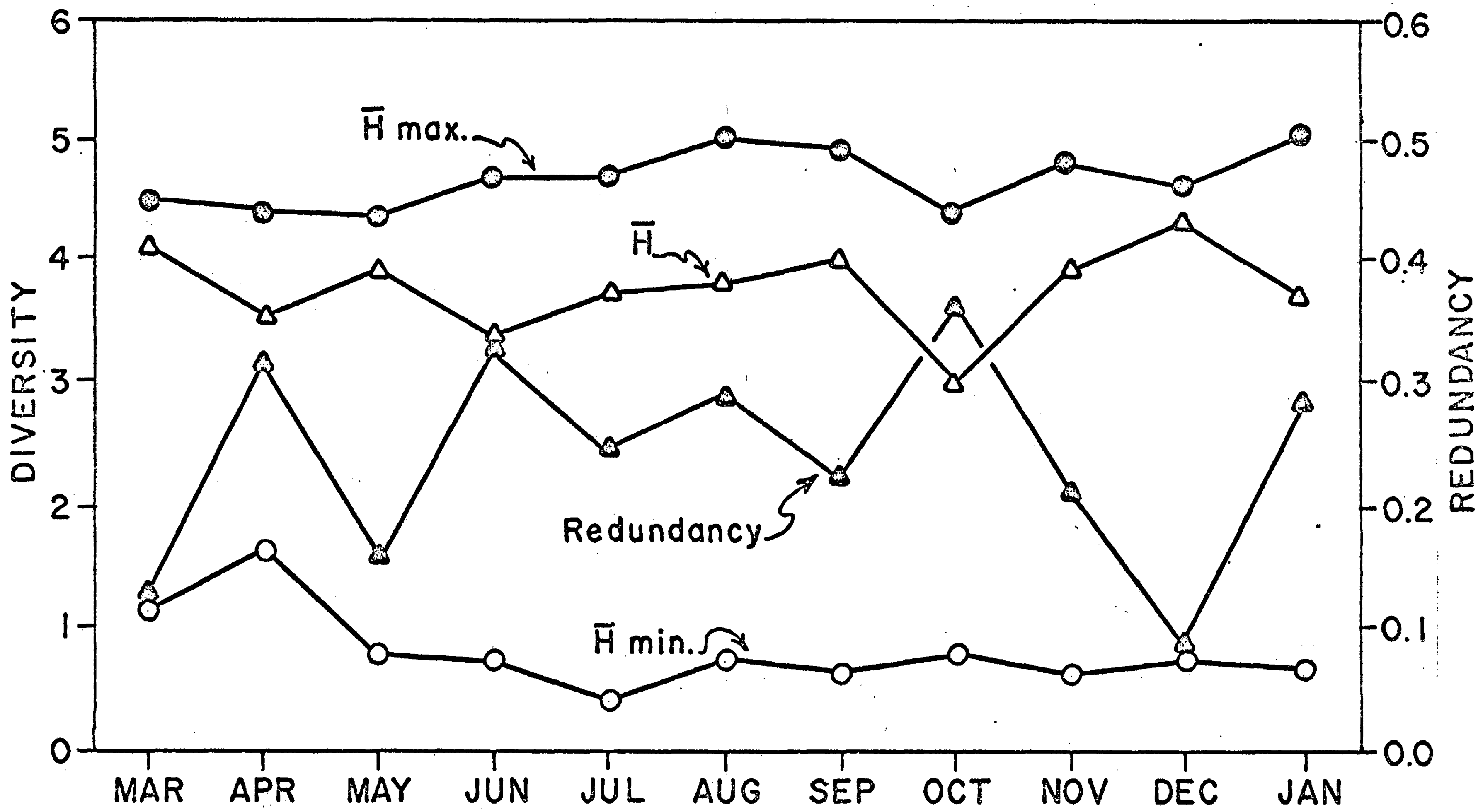

Figure 4. Monthly diversity and redundancy values at Station IV, March 1967 - January 1968.

Early fall shows diversity below mean values at both stations. At Station II-March the slight decrease in diversity ($\overline{H}$ = 3.4663) is due to an overwhelming abundance of Ampelisca bouvieri, Eudorella sp. and Megamphopus sp. which together compose 64.76% of the population. Many of these animals were young, 63% of A. bouvieri were found on the 1 mm screen. Unfortunately the 1 mm screen does not retain all young individuals of the latter two species.

Station IV-April cannot be considered truly representative of a typical soft bottom community because a large amount of epifauna occurred in the sample. Species usually present, such as Ampelisca bouvieri, Rhodine loveni and maldanid #1, did not occur, while other common species occurred in low numbers. Heterophoxus videns and Ammotrypane sp. made up 51% of the sample and this caused a slight lowering of diversity. Since 31 species were represented, diversity remained fairly high even though 22 species were represented by only one or two individuals.

The most conspicuous drop in diversity occurred in late austral winter and early austral spring. It was most pronounced at Station II where diversity values in August and September fell 0.7 and 0.8 bits/individual respectively below the mean. In August Apistobranchus sp. and Thallasodrilus sp. were both very abundant making up 59% of the population while in September Rhodine loveni also became abundant and Apistobranchus sp. tapered off. In this case Thallasodrilus sp. and R. loveni composed 52% of the population.

At Station IV diversity declined in October to a low of 3.0515. Apistobranchus sp., 36% of sample, was twice as abundant as the next most abundant animal. Also contributing to the low $\overline{H}$ was a low number of species (26).

The lowest diversity value calculated (2.6099) occurred at Station II-January. This is attributed to the low number of species (21) in the sample and also the clear dominance of *Ampelisca bouvieri* and *Capitella perarmata* which composed 67% of the sample numerically. Although *A. bouvieri* was a recurrent member of the community, *C. perarmata* occurred in only 3 out of 23 samples and only once in abundance. In this case 68% of the individuals of *C. perarmata* occurred on the 1 mm screen.

Highest diversities occurred in late spring-early summer. At this time diversity values approached theoretical maximums, and no one species dominated the population.

The Environment

Anvers is a continental island less than 10 miles off the coast of the Antarctic Peninsula (Fig. 5). It is 37 miles long and 24 miles wide with an extensive ice cap. Rocky promontories jut from beneath the ice cap along the coast, and are normally growing sites for mosses, lichens and at least one species of flowering plant, *Deschampia antarctica*.

Arthur Harbor lies between two such outcrops, Norsel Point and Bonaparte Point. Temperatures are mild, due to a relatively warm current flowing by the island from the Bellingshausen Sea (Clowes, 1934), and also because low strato-cumulus clouds which normally occur over the harbor retain back-radiation. Temperatures on the ice cap are more extreme. Monthly mean air temperatures fluctuated little throughout 1967 (Fig. 6). The mean annual temperature was -3.41°C. Winds showed slight variations in monthly means (Fig. 6) although storms throughout the year made winds above 40 knots common.

The Adelie penguin, *Pygoscelis adeliae*, breeds on the islets in

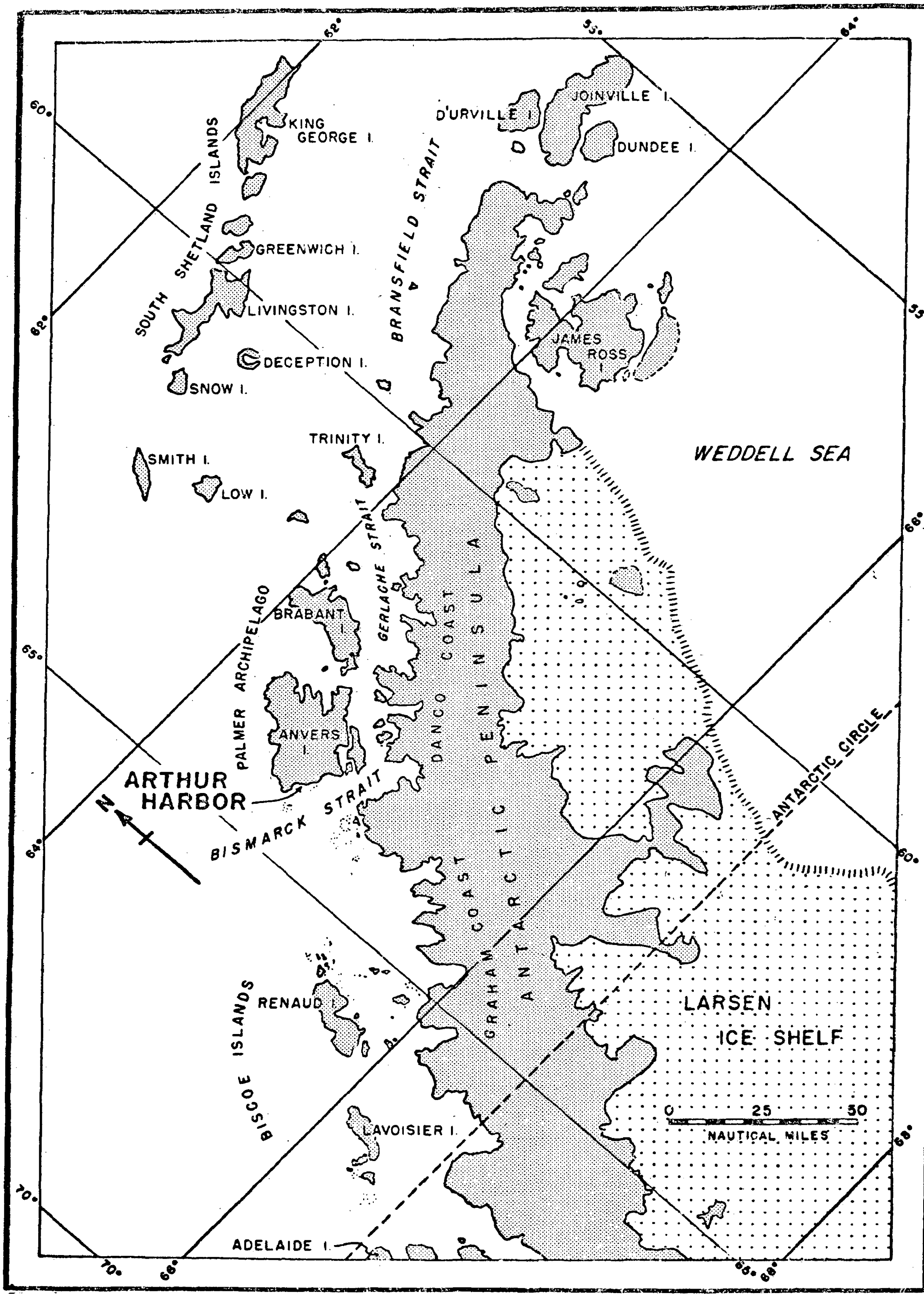

Figure 5. Location of Arthur Harbor, Anvers Island, Antarctica, on the Antarctic Peninsula.

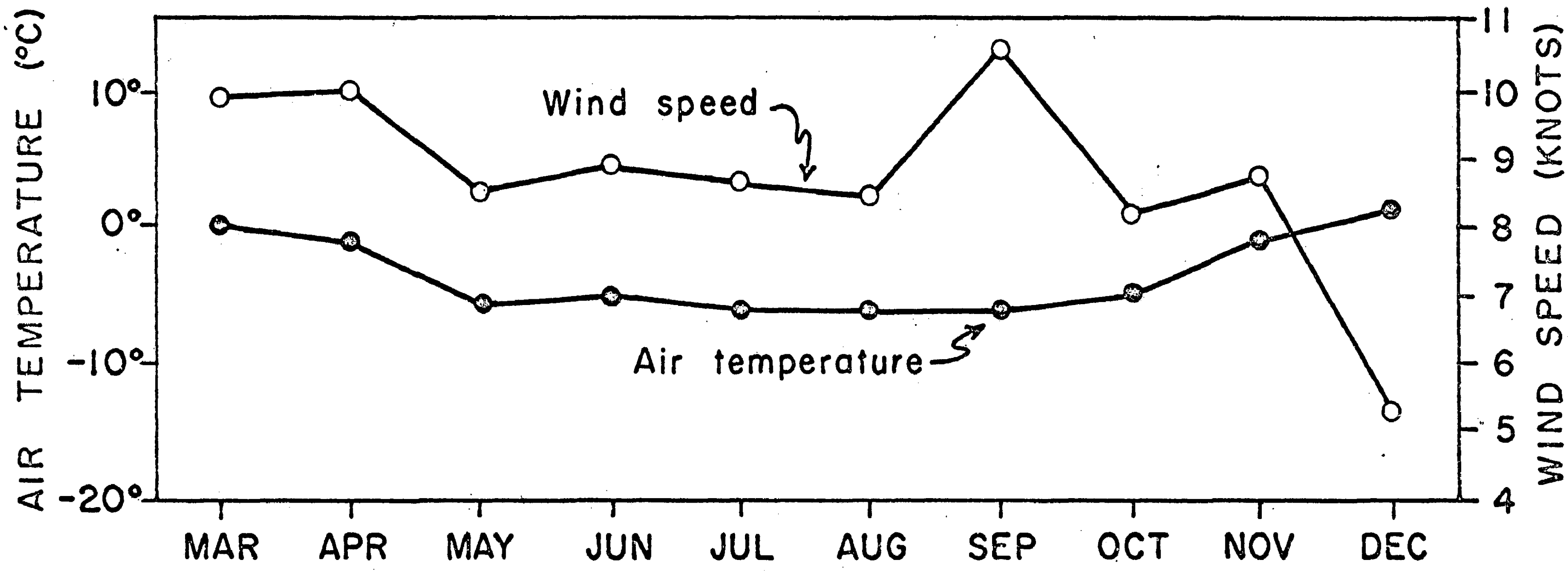

Figure 6. Mean air temperature in °Celsius, and mean wind speed in knots, March 1967 - December 1967.

Arthur Harbor in numbers upwards of 30,000 (Holdgate, 1963). Guano from the rookeries adds considerable nutrients to the harbor during the summer plankton blooms. Other breeding birds in Arthur Harbor include the Brown skua, Catharacta skua, the Giant petrel, Macronectes gigantea, Wilson's storm petrel, Oceanites oceanicus, the Antarctic tern, Sterna vittata, and a small heretofore unreported colony of the Southern Black-backed gull, Larus dominicanus on Bonaparte Point. The Blue-eyed shag, Phalacrocorax atriceps, frequents Arthur Harbor in large flocks throughout the year to feed on fish.

The Weddell seal, Leptonychotes weddelli, occurs in the harbor and has been reported by Dearborn (1965b) to feed mainly on fish, cephalopods and bottom invertebrates. This is also the main food of the Elephant seal, Mirounga leonina, which has a population of about 100 individuals in the harbor during the winter, although the stomach of one female was examined and found to be completely filled with sediment. A pod of about 60 Crabeater seals, Lobodon carcinophagus, was seen feeding on plankton in the harbor on 16 February 1967. Normally small numbers of these seals move in and out of the harbor with the pack ice.

Notothenia coriiceps is the most abundant of the seven species of benthic fish in Arthur Harbor where it occurs throughout the year. N. nudifrons also occurs throughout the year but not in large numbers. Summer fish include N. gibberifrons and Chaenocephalus aceratus. Stomach contents of C. aceratus revealed Euphausia sp. on one occasion, indicating a pelagic feeding habit. Trematomus borchgrevenki, T. bernacchii and T. hansoni occur occasionally in the harbor.

In certain protected areas of Arthur Harbor the intertidal zone supports a characteristic fauna, at least in the summer, living under stones and boulders. Here may be found *Tetrastemma validum*, a small dark brown nemertean which occurred either free living or encased in a transparent sheath. Wheeler (1934) reported the sheaths open at both ends, but Mr. Suydam and I found specimens sealed in the sheath, which also contained eggs. Polychaetes from the intertidal include *Harmothoë megellanica* and *Neanthes kerguelensis*. *Tonicina zschaui* was a common chiton in this zone as was the gastropod *Margarella antarctica*.

The most distinctive invertebrates of this area were the giant amphipods *Paracerodocus miersii* and *Bovallia gigantea*, although the smaller *Eurymera monticulosa* was more abundant. Another common crustacean was the isopod *Cymodocea antarctica*. Characteristic echinoderms included a small unidentified sea star and the bright red holothurian *Psolidium gaini*.

Mr. Suydam and I collected in the intertidal zone of Paradise Bay on 28 December 1967 and found *Harpagifer bispinnis*, a small fish living under rocks and stones and exhibiting elaborate protective coloration. These fish were not collected in Arthur Harbor although they may be present.

The steep rocky submarine cliffs of the harbor collect little sediment and provide a substrate for algae and epifauna. Conspicuous inhabitants include the limpet *Pantinigera polaris*, the ubiquitous rhynchocoel *Lineus corrugatus* and the echinoderms *Odontaster validus* and *Sterechinus neumayeri*.

High primary productivity values have been measured in this area (El-Sayed, Mandelli and Sagimura, 1964; Mandelli and Burkholder, 1966; Horne, Fogge and Eagle, 1969). Horne *et al*. (1969) calculated a primary productivity rate of 130g C/m^2/yr for the area around the

South Orkney Islands. This is similar to the 100g $C/m^2/yr$ estimated by Ryther (1966) for the Southern Ocean. Mandelli and Burkholder found primary productivity values in the Gerlache Strait from 0.58 to 1.20g $C/m^2/day$. If the growing season in this area is considered around 120 days then primary productivity estimates would fall between 70 and 145g $C/m^2/yr$. It may be even higher in an enclosed area such as Arthur Harbor where grazing of the zooplankton by the summer penguin population may reduce it sufficiently to increase phytoplankton production (Horne et al. 1969).

Although the sun is never continuously above the horizon there is sunlight throughout the year at Arthur Harbor. The sun is above the horizon for 12 hours on 21 September and this steadily increases to a peak of almost 22 hours on 21 December when there is continuous daylight. After 21 December a decrease in sunlight duration occurs until on 21 June the sun is above the horizon only 4 hours. During 1967 fast ice occurred in the harbor from June almost continuously until early November.

Sea water temperatures in Arthur Harbor showed slight, though marked, seasonal variation (Table VII). High temperatures for surface (+0.6°C) and bottom (-0.1°C) occurred in January while yearly lows (-1.9°C surface and bottom) occurred in August. This gives an annual range of 2.5°C. The annual mean bottom temperature was -1.0°C. Littlepage (1965) reported a mean sea temperature of -1.81°C from McMurdo Sound. Temperatures at McMurdo Sound remain lower and exhibit less fluctuation than in Arthur Harbor.

Salinity showed little fluctuation throughout the year (Table VIII). However, a seasonal trend is detectable. Maximum salinities occurred during July and August with minimum salinities during the

Table VII. Surface and bottom temperatures in °C for all stations from February 1967 to January 1968.

	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
I												
Surface	-	-0.6	-1.1	-	-	-1.8	-1.9	-1.6	-1.7	-1.4	-0.9	+0.4
Bottom	-	-0.6	-0.7	-	-	-1.8	-1.9	-1.5	-	-1.5	-1.0	-0.1
II												
Surface	-	-0.4	-0.6	-1.3	-1.7	-1.8	-1.9	-1.5	-1.5	-1.5	-0.9	+0.4
Bottom	-	-0.2	-0.6	-1.0	-1.1	-1.8	-1.9	-1.1	-0.8	-1.5	-1.0	-0.1
III												
Surface	-	-0.1	-0.7	-1.3	-	-	-1.9	-1.4	-	-1.6	-	0.0
Bottom	-	-0.3	-0.6	-0.8	-	-	-1.9	-1.5	-1.1	-1.8	-	-0.1
IV												
Surface	-	-0.7	-0.8	-1.4	-1.7	-1.8	-1.9	-1.5	-1.7	-1.6	-	+0.6
Bottom	-	-	-0.6	-0.9	-1.3	-1.8	-1.9	-1.1	-0.6	-1.8	-	-0.1
Surface mean	-	-0.4	-0.8	-1.3	-1.7	-1.8	-1.9	-1.5	-1.6	-1.5	-0.9	+0.4
Bottom mean	-	-0.4	-0.6	-0.9	-1.2	-1.8	-1.9	-1.3	-0.8	-1.6	-1.0	-0.1

Table VIII. Surface and bottom salinities in ‰ for all stations from February 1967 to January 1968.

	Feb.*	Mar.*	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
I												
Surface	-	-	33.441	-	-	-	34.035	33.933	33.765	33.746	33.601	32.852
Bottom	-	-	33.675	34.031	-	-	34.078	34.047	34.066	-	33.969	33.945
II												
Surface	-	-	-	33.871	33.847	-	33.851	33.863	33.773	33.730	33.851	33.269
Bottom	-	-	-	33.965	34.172	-	34.623	34.196	34.227	33.902	33.976	34.129
III												
Surface	-	-	-	33.722	-	34.027	34.090	33.871	-	33.726	33.824	33.016
Bottom	-	-	-	33.887	-	34.274	34.211	34.219	-	33.922	-	34.129
IV												
Surface	-	-	33.476	33.832	33.691	33.406	33.055	33.351	33.750	33.699	33.871	33.398
Bottom	-	-	-	34.149	34.008	34.180	34.258	34.239	34.294	33.930	34.086	34.141
Surface mean	-	-	33.458	33.808	33.769	33.716	33.758	33.754	33.763	33.725	33.787	33.133
Bottom mean	-	-	33.675	34.008	34.090	34.227	34.292	34.175	34.196	33.918	34.010	34.086

*Salinities for this period were lost due to freezing.

summer and early fall. The annual mean bottom salinity was 34.10‰ with a range from 33.68 to 34.62‰. Littlepage (1965) found a similar situation in McMurdo Sound although salinities are generally higher there.

DISCUSSION

Animal Density

Ecologists have not adopted standard techniques for evaluating community studies. Sampling gear includes grabs, cores, and dredges, which take various size samples. Furthermore, animals have been collected on screens varying from 2.0 mm in diameter to less than 0.1 mm. This makes comparisons of studies by benthic investigators difficult.

Ellis (1960) studied the benthos of Foxe Basin and Baffin Bay in the Arctic using different screen sizes in different areas. From 26 samples at Frustration Harbor he obtained a mean of 243 indiv./m^2 using a 2 mm screen. At north Baffin Island, using a 1.5 mm screen, he obtained a mean of 1,295 indiv./m^2 for 51 grab samples. From the shallow waters of Disko Bugt (1 mm screen) and Godthaab Fjord (2 mm screen) the mean for 74 samples was 1,299 indiv./m^2 and from the deeper water of Disko Bugt he obtained a mean of 1,134 indiv./m^2 for 40 grab samples.

From 20 grab samples in Buzzards Bay, Massachusetts, Sanders (1960) calculated a mean of 9,985 indiv./m^2 using a screen size of 0.2 mm. Haven (1967) working in the lower York River, Virginia found a mean value of 4,904 indiv./m^2 for two mud stations (depth 6.1 m, 12.2 m) and a mean value of 44,204 indiv./m^2 for two shallow water sand stations (1.5 m and 3.0 m depth) using a 0.25 mm mesh. If values are calculated for the data from his 1.0 mm screen samples, they range from a mean of 928 indiv./m^2 for the mud stations to a mean of 5,548 indiv./m^2 for the sand stations.

Grassle (1967) sampled on the continental shelf and slope off North Carolina. He found, using a 0.297 mm mesh, a mean of 3,948 indiv./m^2 at three stations on the shelf and a mean of 1,835 indiv./m^2 at four slope stations. Wigley and McIntyre (1964) made a transect on the continental shelf and slope south of Woods Hole, Massachusetts. Results from a 1.0 mm mesh screen indicate a mean of 4,740 indiv./m^2 from the inner shelf, a mean of 1,496 indiv./m^2 from the outer shelf, and a mean of 1,214 indiv./m^2 from the slope.

Finally Sanders et al. (1965), using a 0.2 mm mesh, reported the following results from a transect between Massachusetts and Bermuda: outer continental shelf, 6,000-13,000 indiv./m^2; slope stations, 6,000-23,000 indiv./m^2; abyssal rise, 1,500-3,000 indiv./m^2; abyss under the Gulf Stream, 150-270 indiv./m^2; abyss under the Sargasso Sea, 30-130 indiv./m^2; lower Bermuda slope, 500-750 indiv./m^2.

In Arthur Harbor at Station II samples ranged from 3,264 to 14,756 indiv./m^2 with a mean of 7,629 indiv./m^2. At Station IV the range was 2,244 to 11,747 indiv./m^2 with a mean of 6,285 indiv./m^2. These figures are 5 to 29 times higher than Ellis' Arctic figures, and they are 7 times higher than Haven's estuarine mud station (1 mm screen). This implies a dense concentration of macroinvertebrates in the harbor bottom. The only comparable results are the inner continental shelf stations of Wigley and McIntyre, and the shallow water York River stations of Haven. Wigley and McIntyre considered the benthos at their inner continental shelf stations to be unusually rich and attributed the phenomenon in part to "abundant zooplankton in the overlying water", as deduced from the work of Bigelow and Sears, 1939. It was shown above that the inshore waters along the

Palmer Archipelago are rich indeed in phytoplankton, indicating an extremely rich food source for the benthos.

The Benthic Community

Major components of the community in Arthur Harbor are annelids, crustaceans and mollusks (Fig. 7). Annelids dominate numerically by making up 51% of the population, followed closely by the crustaceans which compose 38%. Mollusks make up 4% and all other groups combined contribute 7%. In volume, however, mollusks dominate with 52%, followed by the annelids with 26% and the crustaceans with 14%. The small groups also contribute 7% to the volume of the population. If percent number and percent volume for each group is added, annelids contribute 78% to the population while mollusks and crustaceans are about equal at 56% and 52% respectively. The remaining groups contribute 14%.

The most characteristic member of the community was *Ampelisca bouvieri*. It occurred in 87% (20 of 23) of all samples collected and ranked third in abundance with a mean of about 570 indiv./m^2. Feeding habits are unknown; however, Enequist (1950) in his fine study of amphipods from the Skaggerak defines two major feeding types in the family Ampeliscidae.

One, characterized by *Haploops tubicola*, can be considered a suspension feeder since it normally sifts detritus from the water by using the second antennae. The tubes are usually built on a soft mud bottom and when finished prevent the antennae from reaching the bottom, thus restricting the species to this mode of feeding. The other type, utilized by species such as *Ampelisca brevicornis*, *A. macrocephala* and *A. tenuicornis*, feeds by scraping the bottom with its second antennae or whirling up sediment with currents provided

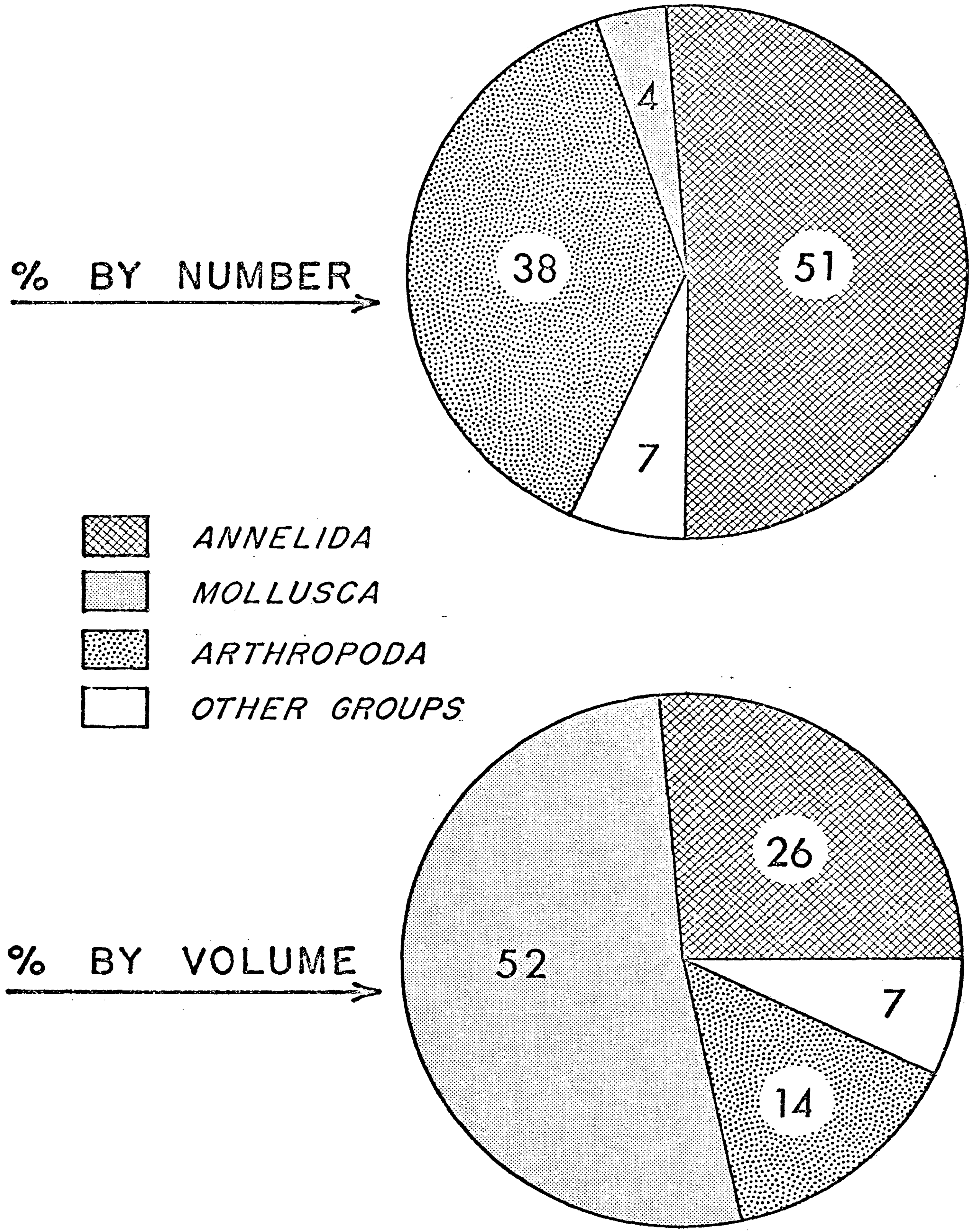

Figure 7. Major components of the soft bottom macrobenthic community of Arthur Harbor by number and volume.

by the second antennae and the pleopods. Mills (1967) separates the latter type into the scrapers which normally occur on soft mud bottoms, and the whirlers, characterized by the sibling species A. abdita, which occurs on fine sand and mud bottoms, and A. vadorum, which occurs on sandier bottoms. Mills further states that any one of the feeding methods may be utilized by any species at a given time, however, each species generally tends toward one method. This makes it very difficult to predict the feeding method of A. bouvieri but since it was twice as abundant on the more muddy bottom of Station II than at Station IV, it is probably not in the whirling category. Also, it has the rather long setae more characteristic of the suspension feeders, thereby reducing its chances of being a scraper. The possibility exists that it might be a suspension feeder during the summer periods when the overlying waters are very productive and a deposit feeder in the winter. This species appears to be confined to South Georgia and the Antarctic Peninsula.

Yoldia eightsi is also a characteristic member of the community. This large nuculanid occurred in 83% of all samples with a mean abundance of about 154 indiv./m^2. Sanders (1956) has indicated that protobranchiate mollusks utilize palp proboscides in feeding and are thus deposit feeders. This appears to be true for Y. eightsi and is substantiated by the fact that it is nearly three times more abundant at Station II than at Station IV. This species, synonymous with Yoldia woodwardi (Dell, 1964), is found in the Falkland Islands, South Georgia, the Palmer Archipelago, the Bellingshausen Sea and the Ross Sea, thus making it known throughout the Western Antarctic.

Apistobranchus sp. is a very small and fragile polychaete previously reported from Arthur Harbor by Hartman, 1967. Its overwhelming abundance (1,110 indiv./m^2) gave it the third highest bioindex value even though it had a mean volume of only 0.0018 ml/indiv. The head is characterized by two long fleshy tentacular palps, each with a ventral groove, however, it is not known how these are used in feeding. Apistobranchus sp. is twice as abundant on the sandier bottom at Station IV than Station II. At present it is known only from the Falkland Islands and the Palmer Archipelago.

In marine benthic community studies, oligochaetes have played a small role, mainly because there are few marine species which usually do not occur in large numbers. Furthermore they are normally very small and difficult to identify. Sanders (1956, 1960), Jones (1961) and Grassle (1967) all reported oligochaetes in their benthic studies but in no instance did they appear as important members of the community. Thallasodrilus sp. is the second most abundant macro-invertebrate in Arthur Harbor. It occurred in all samples except one and reached its peak in September (5,372 indiv./m^2). Thallasodrilus sp. had a mean abundance of 766 indiv./m^2, and was the most abundant animal at Station II. This may reflect its feeding habits as a deposit feeder, for it ranked fifth at Station IV. Thallasodrilus sp. is known only from Arthur Harbor, Antarctica.

Maldanid polychaetes were well represented in the community. Rhodine loveni occurred in 78% of all samples taken. This cosmopolitan species represented about 260 indiv./m^2 and was twice as abundant at Station II as at Station IV. Another characteristic maldanid in the community was the unidentified maldanid #1. This small species occurred in 78% of all samples with a density of approximately 170 indiv./m^2.

Haploscoloplos kerguelensis had the third highest bioindex value at Station IV and ranked second in abundance. At Station II, where it was not so abundant, it occurred in 11 out of 12 samples while at Station IV it occurred in every sample. Number of individuals represented was about 328 indiv./m^2 for this species which reached its peak in July and August. H. kerguelensis is known from the Kerguelen and the Falkland Islands. It also extends from South Georgia through the South Orkneys and down the Palmer Archipelago.

Other species occurring consistently from month to month either did not maintain large numbers of individuals per square meter, or did not displace a large proportion of the total volume. Some polychaetes in this category include Ammotrypane sp., Paraonis sp. and the large nephtyid Aglaophamous ornatus. Among the crustaceans, Eudorella sp., the fourth most abundant species at Station II, occurred in 87% of all samples. Nototanais antarcticus occurred in every sample at Station II, however, it was nearly absent from Station IV. Amphipods were well represented in the community and made up a relatively stable segment. Many species were consistently sampled from month to month. Each of the seven most abundant species of both amphipods and polychaetes occurred in at least 75% of all samples taken. Yoldia eightsi was the only mollusk in this category.

Other animals such as Laternula elliptica, Sterechinus neumayeri and Abatus cavernosus were only rarely sampled; however, when taken they represented a large proportion of the volume for that particular sample.

Endemism

Endemism is a well known phenomenon in the Southern Ocean. Hartman (1966), after considering all nominate species of polychaetes from the Southern Ocean concluded that the Antarctic and Subantarctic has a high rate of endemism. Kott (1969) found a high degree of endemism among genera, as well as species, of ascidians. She also found that endemics were not restricted to local areas but in many cases were circumpolar, which led her to believe that the ascidian fauna is a relict of a more ancient fauna. Ekman (1953), realizing that although the fauna was well known taxonomically it was not complete, reported at the species level: polychaetes 50% endemic, amphipods 70-75%, isopods 75%, and echinoderms 75%.

In Arthur Harbor 89% of the benthic fauna appears to be endemic to the Southern Ocean. This is higher than one might expect from the preceding figures, and may be the result of the small screen size and the intensive sampling program. Most smaller groups, such as the rhynchocoels, ostracods, cumaceans, nebaliaceans, pycnogonids, echinoderms, and ascidians were completely endemic at the species level. In the three main groups, the mollusks were all endemic at the species level, while the amphipods exhibited 95% endemism and the annelids 77%. If all species in the latter two groups were identified, the figures would probably rise. When endemic genera are considered, the mollusks possess 21%, the amphipods 48% and the annelids 13%. Compared with most other areas of the world these figures are very high and reflect the long stability of this unique environment.

Community Stability

Grassle (1967) studied the effects of environmental variation on species diversity. He found that in a more stable environment such as the continental slope (temperature variation, 0-4°C) diversity was higher than in a less stable area such as the shallow water continental shelf (temperature variation, 18°C). Grassle explained his results in terms of the theory of environmental stability (Klopfer, 1959). Thus in a stable environment species are able to maintain smaller niches, thereby allowing more species to occupy the system. Genetic variability (the ability of at least part of a population to withstand environmental change) will be selected against in a stable environment, thus allowing energy used for maintenance of the population in a less stable environment to be used for production. Speciation may then occur at a more rapid rate. The population in general will be more stenotopic and fluctuations in population size will be caused by biotic and not abiotic factors (Margalef, 1963). Production of offspring will tend toward brooding, thus allowing for production of fewer offspring and less expended energy. Longevity may also increase thereby lowering productivity. Communities which exhibit many of the preceding properties include the deep-sea communities studied by Hessler and Sanders (1967), the slope community of Grassle (1967) and some tropical shallow water communities reported by Sanders (1968).

From the data it appears that the shallow water benthic community of Arthur Harbor also possesses many of these characteristics. Physical parameters are those of a non-stress environment. Yearly bottom temperature fluctuations were less than 2°C and bottom salinities varied less than 0.6‰. Littlepage (1965) reported oxygen values from 6.08 to 8.59 ml/liter at McMurdo Sound. Bunt (1960) found summer values at Mawson as high as 12.9 ml/liter and winter values as low as 5.8 ml/liter. In no case could oxygen be considered limiting in these areas and this is also probably true in Arthur Harbor.

Members of the community reflect the influence of this stability.

Many species brood their young. Abatus cavernosus has very large marsupia in the test, while the young of Rhodine loveni pass through their larval stages in the sand grain tube. Other common species observed brooding include Ampelisca bouvieri, Eudorella sp. and Nototanais antarcticus. Hartman (1967) reported one polychaete, Nothria notialis, a very common species in the Bransfield Strait, which builds lateral capsules along its tube. These capsules are brood chambers which contain various stages of developing young. She reports that "the oldest capsules are at the basal end and the youngest at the distalmost end of the series". Pearse (1969) found that Odontaster validus produced bipinnaria larvae. However, they were very slow developers (40-55 days) and were demersal during most of their development. Thorson (1950) has stated that as many as 95% of all polar species may have direct development. The stability of the community is thus increased by insuring the greatest protection during the most sensitive period in the life cycle, by recruitment of species in the same area from which they came, and by reducing oscillations in the population from year to year (Thorson, 1957).

Since most members of the community are deposit feeders, the food source is derived from organic material in the sediment which ultimately comes from the plankton. Primary productivity was shown above to be high in the Arthur Harbor area. Margalef (1963) has stated that a net transfer of energy exists between the plankton and the benthos. In this case the reaction proceeds in favor of the benthos since it gives up little energy to the plankton in the form of pelagic larvae. This large input of energy is realized by the density of individuals in the benthic community. It was shown earlier that infaunal individuals are denser in Arthur Harbor than in most other areas from which data are available. These large numbers of animals must be expected to lower the diversity of the community, and this in part appears to be true.

Mean diversity values at Station II (3.9866) and at Station IV (3.7500) are comparable to Haven's values (3.3096-3.7604) for the York River. They are much higher than the values calculated by Grassle (1967) for Sanders' "R" stations in Buzzards Bay (1.5575-3.4658) where yearly primary productivity rates are comparable but physical parameters vary greatly. But when compared with the stable slope stations studied by Grassle off the North Carolina coast they appear low. Grassle found mean values of 4.770 and 4.780. However, the density of animals in Arthur Harbor appears to be at least three times greater than on the slope off North Carolina. This high population density lowers the maximum theoretical diversity. But the evenness of the community as measured by redundancy indicates that although diversity values superficially appear lower than expected, they are very close to the maximum theoretical diversity possible for the community (Figs. 6 and 7).

Thus there appear to be generally opposing forces shaping the structure of the community. A passive force in the form of stable environment allows for high diversity, complexity, and stability (Lloyd, Zar and Karr, 1968) and an active force in the form of a rich food supply tends to increase density and lower diversity (Margalef, 1963).

Community Comparisons

Although physical conditions such as temperature and salinity are similar between Arthur Harbor and McMurdo Sound there appears to be little similarity in the fauna. This seems irregular, considering the circumpolarity attributed to Antarctic fauna. The differences may in fact result from differences in bottom types.

Dearborn (1965a) found five bottom types in McMurdo Sound, none of which appears to resemble very closely the Arthur Harbor substrate. Near shore in 20 to 30 m of water he found volcanic sand, gravel and cobble. This was the only area in which *Yoldia eightsi* was taken, and was the most common habitat of *Laternula elliptica*. Other widely known Antarctic species reported from all bottom types by Dearborn included *Odontaster validus*, *Lineus corrugatus*, *Neobuccinum eatoni*, and *Glyptonotus antarcticus*. Unfortunately, groups such as polychaetes and amphipods were given little consideration. Dearborn's bottom type 5, composed of silty to sandy mud, may show some similarities since the dominant animals were small tubicolous polychaetes. This bottom was encountered at various depths on the western side of McMurdo Sound. The most common bottom encountered by Dearborn occurred between 40 and 400 m and was composed of mats of siliceous sponges up to a meter in height. Important community members were colonial coelenterates and ectoprocts; however, the assemblage was dominated by sponges of the family Rossellidae.

Dearborn found that for groups such as mollusks, crustaceans and brachiopods, genera and species were not particularly diverse and numbers of individuals were quite high. He concluded that in McMurdo Sound, filter feeders, carnivores, and scavengers were well represented but that deposit feeders were scarce.

Bullivant (1967), working in the Ross Sea, found that where mud bottoms were sampled, mollusks, polychaetes, echinoderms, and crustaceans dominated, but on hard substrates, coelenterates, sponges, ectoprocts, and barnacles became dominant. These results appear to be in agreement with those of Russian investigators in East Antarctica. Uschakov (1963) reported that most of the shelf fauna along the Sabrina coast and in the Davis Sea was composed of filter feeders with sponges and ectoprocts being dominant.

These communities have little in common with the soft bottom community of Arthur Harbor where deposit feeders are well represented, but filter feeders are scarce; and where, although numbers of individuals are high, genera and species are quite diverse. Further work now in progress (McCain and Stout, 1969) in Arthur Harbor on the rocky submarine cliffs may show closer relations to the Ross Sea and East Antarctic communities.

Preliminary investigations thus indicate that most areas on the continental shelf in the Ross Sea and the East Antarctic harbor hard bottom communities, whereas in Arthur Harbor on the Antarctic Peninsula a typical soft bottom community exists.

SUMMARY

1. The bottom of Arthur Harbor was mainly soft mud below 30 m. Bottom salinity (yearly mean, 34.10‰) and bottom water temperature (yearly mean, -1.0°C) showed little variation throughout the year.
2. The benthic soft bottom community was composed of at least 110 species distributed among 10 phyla.
3. The density of macrofauna was 7,620 indiv./m^2 at Station II and 6,285 indiv./m^2 at Station IV.
4. Major components of the community by number were annelids, 51%; arthropods, 38%; and mollusks, 4%; and by volume mollusks, 52%; annelids, 26% and arthropods, 14%.
5. Bioindex values utilizing numbers and volumes indicated Ampelisca bouvieri and Yoldia eightsi were dominant and characteristic members of the community.
6. At least 18 species were recurrent members of the community occurring in 75% of all samples.
7. Eighty-nine percent of species in the community were found to be endemic to the Southern Ocean.
8. Mean diversity values were 3.9866 bits/individual at Station II and 3.7500 bits/individual at Station IV, and mean redundancy values were 0.1947 and 0.2370 respectively.
9. The data indicated a stable, complex, and relatively diverse community.

10. The community showed little faunal affinity to previously described Antarctic benthic communities.

LITERATURE CITED

Bullivant, J. S. 1967. Ecology of the Ross Sea benthos. The fauna of the Ross Sea. Part 5. N. Z. Dep. Sci. Industr. Res. Bull. 176: 49-74.

Bunt, J. S. 1960. Introductory studies hydrology and plankton, Mawson, June, 1956, February, 1957. Australian Natl. Antarctic Res. Expeditions Reps., Series B, 1-135.

Clowes, A. J. 1934. Hydrology of the Bransfield Strait. Discovery Reps. 9: 1-64.

Dearborn, J. H. 1965a. Ecological and faunistic investigations of the marine benthos at McMurdo Sound, Antarctica. Ph.D. Thesis, Stanford Univ. (Libr. Cong. Card No. Mic. 65-12765) 238 p. Univ. Microfilms. Ann Arbor, Mich. (Diss. Abstr. 25: 4899).

Dearborn, J. H. 1965b. Food of Weddell seals at McMurdo Sound, Antarctica. J. Mammal. 46(1): 37-43.

Dearborn, J. H. 1967. Stanford University invertebrate studies in the Ross Sea 1958-61: general account and station list. The fauna of the Ross Sea. Part 5. N. Z. Dep. Sci. Industr. Res. Bull. 176: 31-47.

Dearborn, J. H. 1968. Benthic invertebrates. Australian Natur. Hist. 16(4): 134-139.

Dell, R. K. 1964. Antarctic and Sub-antarctic Mollusca: Amphineura, Scaphopoda and Bivalvia. Discovery Reps. 33: 93-250.

Dunbar, M. J. 1968. Ecological development in polar regions. A study in evolution. Prentice-Hall, Inc., Englewood Cliffs, N. J. 119 p.

Ekman, S. 1953. Zoogeography of the seas. Sidgewick and Jackson Ltd., London. 417 p.

Ellis, D. V. 1960. Marine infaunal benthos in Arctic North America. Arctic Institute of North America. Tech. Paper No. 5. 53 p.

El-Sayed, S. Z., E. Mandelli, and Y. Sagimura. 1964. Primary organic production in the Drake Passage and Bransfield Strait. Antarctic Res. Ser. 1:1-11.

Enequist, P. 1950. Studies on the soft-bottom amphipods of the Skagerrak. Zool. Bidrag. Fran Uppsala. 28:297-492.

Grassle, J. F. 1967. Influence of environmental variation on species diversity in benthic communities of the continental shelf and slope. Ph.D. Thesis, Duke Univ. (Libr. Cong. Card No. Mic. 68-2723) 194 p. Univ. Microfilms. Ann Arbor, Mich. (Diss. Abstr. 28:3926B).

Hartman, O. 1966. Polychaeta Myzostomidae and Sedentaria of Antarctica. Antarctic Res. Ser. 7:1-158.

Hartman, O. 1967. Polychaetous annelids collected by the USNS Eltanin and Staten Island cruises, chiefly from Antarctic seas. Allan Hancock Mono. in Mar. Biol. No. 2:387 p.

Haven, D. S. 1967. An animal-sediment study in the lower York River, Virginia, p. 1-18. In Concentration of suspended radioactive wastes into bottom deposits. Final Report to U. S. A. E. C. Contract No. AT-(40-1)-2789.

Hessler, R. R., and H. L. Sanders. 1967. Faunal diversity in the deep-sea. Deep-Sea Res. 14:65-78.

Holdgate, M. W. 1963. Observations of birds and seals at Anvers Island, Palmer Archipelago, in 1955-57. British Ant. Surv. Bull. No. 2:45-51.

Horne, A. J., G. E. Fogg, and D. J. Eagle. 1969. Studies in situ of the primary production of an area of inshore Antarctic Sea. J. Mar. Biol. Ass. U. K. 49(2):393-405.

Jones, M. L. 1961. A quantitative evaluation of the benthic fauna off Point Richmond, California. Univ. Calif. Pub. in Zool. 67(3):219-320.

Klopfer, P. H. 1959. Environmental determinants of faunal diversity. Amer. Natur. 93:337-342.

Kott, P. 1969. Antarctic Ascidiacea. Antarctic Res. Ser. 13:1-239.

Krumbein, W. C., and F. J. Pettijohn. 1938. Manual of sedimentary petrography. Appleton-Century-Crofts, New York. 549 p.

Littlepage, J. L. 1965. Oceanographic observations in McMurdo Sound, Antarctica. Antarctic Res. Ser. 5:1-37.

Lloyd, M., J. H. Zar, and J. R. Karr. 1968. On the calculation of information-theoretical measures of diversity. Amer. Midl. Natur. 79(2):257-271.

Mandelli, E. F., and P. R. Burkholder. 1966. Primary productivity in the Gerlache and Bransfield Straits of Antarctica. J. Mar. Res. 24:15-27.

Mare, M. F. 1942. A study of a marine benthic community with special reference to the micro-organisms. J. Mar. Biol. Ass. U. K. 25(3):517-554.

Margalef, R. 1963. On certain unifying principles in ecology. Amer. Natur. 97(897):357-374.

Margalef, R. 1968. Perspectives in ecological theory. The Univ. Chicago Press, Chicago, Ill. 111 p.

McCain, J. C., and W. E. Stout. 1969. Benthic zonation on submarine cliffs in the vicinity of Arthur Harbor, Antarctica. Antarctic J. United States 4(4):105-106.

Mills, E. L. 1967. The biology of an ampeliscid amphipod crustacean sibling species pair. J. Fish. Res. Bd. Canada 24(2):305-355.

Patten, B. C. 1962. Species diversity in net phytoplankton of Raritan Bay. J. Mar. Res. 20(1):57-75.

Pearse, J. S. 1969. Slow developing demersal embryos and larvae of the Antarctic sea star Odontaster validus. Mar. Biol. 3(2): 110-116.

Petersen, C. G. J. 1911. Valuation of the sea. I. Animal life of the sea bottom, its food and quantity. Rep. Danish Biol. Sta. 20:81 p.

Petersen, C. G. J. 1913. Valuation of the sea. II. The animal communities of the sea bottom and their importance for marine zoogeography. Rep. Danish Biol. Sta. 21:44 p.

Petersen, C. G. J. 1914. Appendix to report 21. On the distribution of the animal communities of the sea bottom. Rep. Danish Biol. Sta. 22:7 p.

Powell, A. W. B. 1965. Mollusca of Antarctic and Sub-antarctic seas, p. 333-380. In J. Van Mieghem and P. Van Oye [ed.] Biogeography and ecology in Antarctica. Dr. W. Junk Publishers, The Hague.

Richards, S. W., and G. A. Riley. 1967. The benthic epifauna of Long Island Sound. Bull. Bingham Oceanogr. Coll. 19(2):89-135.

Ryther, J. H. 1963. Geographic variations in productivity, p. 347-380. In M. N. Hill [ed.] The sea. II. John Wiley & Sons, New York.

Sanders, H. L. 1956. Oceanography of Long Island Sound, 1952-1954. X. The biology of marine bottom communities. Bull. Bingham Oceanogr. Coll. 15:345-414.

Sanders, H. L. 1960. Benthic studies in Buzzards Bay. III. The structure of the soft-bottom community. Limnol. Oceanogr. 5(2):138-153.

Sanders, H. L. 1968. Marine benthic diversity: a comparative study. Amer. Natur. 102(925):243-282.

Sanders, H. L., R. R. Hessler, and G. R. Hampson. 1965. An introduction to the study of the deep-sea benthic faunal assemblages along the Gay Head-Bermuda transect. Deep-Sea Res. 12:845-867.

Shannon, C. E. 1948. A mathematical theory of communication. Bull. Syst. Tech. J. 27:379-423, 623-656.

Thorson, G. 1950. Reproductive and larval ecology of marine bottom invertebrates. Biol. Reviews 25:1-45.

Thorson, G. 1957. Bottom communities (sublittoral of shallow shelf), p. 461-534. In J. W. Hedgpeth [ed.] Treatise on marine ecology and paleoecology. I. Ecology. Geol. Soc. Amer. Mem. 67.

Uschakov, P. V. 1963. Quelques particularites de la bionomie benthique de l'Antarctic de l'Est. Cah. Biol. Mar. 4:81-89.

Wheeler, J. F. G. 1934. Nemerteans from the South Atlantic and Southern Oceans. Discovery Reps. 9:215-294.

Wigley, R. L., and A. D. McIntyre. 1964. Some quantitative comparisons of offshore meiobenthos and macrobenthos south of Martha's Vineyard. Limnol. Oceanogr. 9(4):485-493.

VITA

James Kenneth Lowry

Born in Kansas City, Missouri, 2 October 1942. Graduated from Chuckatuck High School, Chuckatuck, Virginia, June 1960. Attended Chowan Junior College from September 1960 to June 1962. Received a Bachelor of Arts degree from the University of Richmond, Richmond, Virginia, February 1965.

Entered The College of William and Mary, June 1965, in the graduate program of the School of Marine Science. Worked as a collector of marine animals in the United States Antarctic Research Program (USARP) during 1967 at Anvers Island, Antarctica, where the field research for this thesis was carried out.